Comment on "Femtosecond wave-packet dynamics in cesium dimmers studied through controlled stimulated emission"

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Abstract

L. Yuan et al. in Phys.Rev.A, 81, 053405 (2010) present excellent experimental results on the dynamics of selective population transfer during the period of vibration motion of cesium molecules. Here we propose its physical explanation, which is based on the concept of inequality of forward and reversed processes in optics.

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The authors observe subtle and interesting effect of selective deexcitation of cesium molecules by delayed femtosecond control laser pulse during one period of its vibration motion [1]. When the delay time equals to half of period of molecular vibrational motion (T/2), the authors observe deexcitation of molecules, which correspond to main frequency of vibrations (34 cm^{-1}). When the delay time of the control pulse equals to T/4 or 3T/4, the deexcitation of molecules with overton frequency (68 cm^{-1}) is observed. Correct physical explanation of the observed phenomenon has obvious interest.

Quite specific method of scientific research becomes firmly established for many years in the field of quantum physics. We name it for ourselves as an accounting physics. Mathematicians propose some models or equations (for example, the Bloch equations or Gross-Pitaevskii equation), which frequently give beautiful description of experimental results. However, at the same time a physical mechanism and physical nature of phenomena usually remain unclear. The proposed "physical explanations" have unintelligible and fantastical character. For example, there are the concepts of "wave packets interference", coherent states (superposition of states). The last concept supposes that atoms or molecules can exist for a long time in some mixture of different quantum states. This concept has quite exact everyday life analogue: "to be slightly pregnant".

The authors of [1] for interpretation of their experimental results use the widespread concept of "wave packets interference". From the wave theory point of view for a superficial first sight this expression looks acceptably. But from the quantum point of view it looks like a full nonsense. The molecules, which are excited by the pump pulse, must "interfere" with other remote molecules, which are excited by control laser pulse. As a result of such "interference" the initially

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excited molecules turn out in the ground electronic state and corresponding excitation energy vanish in unknown way (annihilate?). Of course, the energy can not disappear. It can be emitted in a stimulated way. Real physical explanation of the phenomenon should answer why and how this stimulated emission takes place.

Our physical explanation of the presented in [1] experimental results (also as many other results in nonlinear optics) is based on the concept of inequality of forward and reversed processes in optics [2]. As a fact this explanation is quite similar to lose, which was proposed recently for explanation of other interesting effect: optical precursor phenomenon in an atomic gas [3, 4].

At the first step the cesium molecules absorb the photons. For distinctness we shall propose that at this moment the atoms in molecules move away from each other. Part of this molecules remains in the excited state. But the most part of excited molecules, obviously, immediately return in the ground state after stimulated emission process. However, the atoms change slightly its position and this will be only partially reversed transition, which has differential cross-section smaller, than for fully reversed transition, but greater, than for forward transition [5]. As a result the molecules in the ground state obtain some additional entropy or memory about the initial state. This property corresponds to the concept of a superposition of states in the accounting physics. This memory manifests itself in the interaction of molecules with the control pulse: the absorption cross-section sharply increases but only for the fixed position of atoms.

Then after the absorption of a photon from the control pulse two different variants are possible:

1 - The molecule emits photon and returns exactly into the initial state after fully reversed transition. However, the atoms must slightly else approach each other for this. It takes place only at the phase T/2 for the main frequency of vibration (34 cm^{-1}) and at the phase T/4, 3T/4 for the second-harmonic frequency (68 cm^{-1}). In this case the control pulse returns all molecules in the initial state and "erases" previously written information (memory).

2 - The excited molecule exists in the phase 0, T for the main frequency or 0, T/2, T for its overtone. In this case the atoms continue to move away from each other and fully reversed transition is impossible. It is possible again only partially reversed transition in the ground state with even smaller differential cross-section. In this case the memory is not erased and the number of molecules in the excited state increases.

All details of the proposed semiclassical physical explanation are not fully clear now. It should be studied and discussed. But this physical explanation has reliable physical base (the concept of inequality of forward and reversed processes in quantum physics), which appeared not suddenly and not yesterday. The concept of "wave packets interference" can not be seriously considered as an alternative physical explanation: this is only a meaningless set of words.

Quite similar processes take place in the case of rotational motion of molecules. In this direction the impressive experimental results were obtained [6 - 8]. Although, the authors do not understand with what thing they really have to

do.

So, the most important task now is an experimental study of relation of differential cross-sections of forward, fully and partially reversed processes in quantum physics.

In conclusion, we call upon our scientists to stop growth of the accounting physics and to begin at last a deliberated and directed study of quantum physics, which includes strong time noninvariance [9].

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